Abstract

Background: The aim of this study was to determine the effectiveness of UK Government Covid-19 safe offices policy to increase stair-use in a higher education setting during the Covid-19 pandemic.

Methods: Automated counts at three Ground Floor staircases and the elevator entrances were used to estimate stair to elevator use ratio for ascent and descent from/to the Ground Floor of a University building at Baseline (January to March 2020), First and Second Intervention Months (October 2020, November 2020, respectively). Stair promoting signage and a one-way system was implemented, in line with Government policy.

Results: At Baseline, stair to elevator use ratio for ascent from and descent to the Ground Floor was 1.36 ± 0.02 and 1.88 ± 0.02 people, respectively. The ratio significantly increased in the first intervention month to 2.64 ± 0.09 and 3.96 ± 0.22 people for ascent and descent, respectively. However, the ratio decreased between the First and Second Intervention Months to 1.63 ± 0.06 and 3.05 ± 0.52 people for ascent and descent respectively.

Conclusion: UK Government Covid-19 policy was effective at increasing stair use in a higher education setting.

Background

Throughout the coronavirus (Covid-19) pandemic, United Kingdom (UK) politicians and healthcare providers have stressed the importance of maintaining physical activity levels as a preventative strategy to minimise the risk of adverse Covid-19 effects. However, the first lockdown (23rd March 2020 – 19th June 2020) resulted in 3.4 million more adults in England self-reporting an inactive lifestyle (less than 30-minutes of moderate intensity activity per week), a 7.4% increase in comparison to the same time period in 2019 [1]. The increase in inactivity will be problematic for Health Care providers as National Health Service estimated costs of inactivity were £450 million per year in 2016 [2].

On 11th May 2020, the UK Her Majesty's (HM) Government released working guidance documents for businesses to create 'Covid-19 secure' environments to minimise the risk of transmission amongst colleagues and workplace visitors [3]. One such guidance strategy to minimise colleagues and visitors from moving in close proximity of one another within indoor settings was to promote stair instead of elevator use and implement one-way walking routes through buildings [3]. Concomitantly, stair promoting signage and making staircases the primary visual cue at building entrances have been routinely used to increase physical activity and implement 'active buildings' [4,5]. A recent meta-analysis of 50 stair-promoting studies estimated participants were 52% (95% confidence interval 37 – 70%) more likely to use the stairs following exposure to promotional signs [4]. The authors argued that the evidence of promotional signage is long standing but there has been a lack of scaling up into the wider population and implementation into policy [4]. Due to the Covid-19 pandemic, we now see the adoption of stair promotion signage into health and safety guidance [3], albeit in a health protection rather than health promotion context. The efficacy of this guidance within Higher Education settings is pertinent due to widespread concerns that the mass movement of students to University cities/towns could exacerbate the spread of Covid-19.

The current research, was an opportunistic quasi-experiment to determine the change in stair-use, and thus physical activity, through the implementation of HM Government guidance for working safely in offices and contact centres during Covid-19 [3] by a Higher Education Institution's Estates and Campus Services team. The aim of the study was to determine the magnitude and direction of change in stair to elevator use ratio between pre-Covid-19 and the return to work during Covid-19 timeframes. This research is the first of a two-part Sport and Physical Activity Group (SPAG) project. The follow-up research will explore students' and staffs' opinions about the promotional signage and one-way system implementation as a co-creative process to design stair promoting signage that can be installed across campus following the passing of 'Covid-19 times'.

Methods

Location

This United Kingdom based University has three multi-storey public buildings on its main campus (Learning Hub, Creative Hub, Senate), each having a unique floor plan (see building 360˚ tours to explore the floor plans: [6]). The Learning Hub, a five-storey building, was chosen for observation as it is the main building for teaching, offices and library services, as well as the close proximity of identification access barriers to staircases and elevator entrances. Monitoring of stair and elevator use focused on ground floor ascent and descent only as access barriers were only installed for ground floor elevators and staircases (figure 1). Participants were staff, students, and visitors to the University, however, there were no means of identifying individual characteristics within the access barrier data. Ethical approval for this research was provided by the University's Faculty of Health, Education and Society Ethics Committee (FHSRECHEA000245). This quasi-experimental research is part of the University's Sport and Physical Activity Group's (SPAG) active campus project. The authors had no input into the intervention design. Due to the intervention being a response to Covid-19 it was not possible to conduct a staggered analysis of measures put in place for the stair use and for the elevator use. As such, this paper provides evidence of the effect of all the measures conducted simultaneously. The study methods and analysis were registered retrospectively once the authors had received anonymous access barrier data from the Campus Security Team [7].

Intervention

Prior to the implementation of HM government building guidance due to Covid-19 [3], there were four shared building entry/exit options, four staircases located across the ground floor, and a main elevator shaft with three 'cars' within the ground floor foyer. Identification card access barriers were installed at the ground floor entrance to the elevators and at either the base or landing of each ground floor staircase. The proximity of access barriers to staircases and elevators meant people passing through the access barriers were doing so for the sole purpose of using/had used the

staircases and elevator in all locations except for the 'Market Staircase', which had a small staff office and toilets that could also be accessed (figure 1).

HM Government guidance for working safely in offices and contact centres was first published on 11th May 2020 [3]. Recommendations within the aforementioned report that directly related to building navigation were:

1. Reducing maximum occupancy for lifts, providing hand sanitiser for the operation of lifts and encouraging use of stairs wherever possible.

2. Restricting access between different areas of a building or site.

3. Using visual communications, for example, whiteboards or signage, to explain changes to schedules or breakdowns without the need for face-to-face communications.

4. Using markings and introducing one-way flow at entry and exit points.

In preparation for the commencement of the 2020-21 academic year, which began on 28th September 2020, the University's Estates & Campus Services Department implemented a range of interventions congruently. A semi-structured one-way entry and exit system was implemented with the automated doors of the 'Foyer Entry' and 'Restaurant Entry' points locked to only allow people to exit the building through these doors (figure 1; table 1) thus, people could only enter the building through the 'Market Entry' and '24-hour Entry', however it was still possible to exit the building through these Entry points (as fire exit routes). Furthermore, access barriers were also evenly split to only allow either entry or exit to/from staircases and elevators. The 'Market Mezzanine' staircase and access barriers were permanently locked to prevent entry to the mezzanine social space and therefore, these access barriers were not analysed in the current research. In addition, a series of signage were implemented around the ground floor elevator entry to encourage stair use "Please use stairs if possible" and elevator rule compliance "Only 1 person per lift at any time". Elevator rule compliance signs were located on each floor by elevator entrances as well as a stair-use

encouragement slide, “Please only use the lift if you are unable to take the stairs”, which ran for 10 seconds in a 4 – 9 minute Slide Deck rotation on the televisions opposite elevator entrances on floors 1 – 4.

Table 1. Overview of building and access barrier entry and exit changes between pre and post-Covid-19.

-insert Table 1 here -

- Insert colour Figure 1 here –

Figure 1. Learning Hub ground floor floorplan and signage following changes due to Covid-19 Government guidance.

Stairwell Appearance

No amendments to the staircases’ appearances were made throughout the study period (figure 2). Each staircase had a minimalist aesthetic with whitewashed walls and no ambient music in any of the building’s rooms. The ‘Market Staircase’ and ‘Foyer Staircase’ as well as the elevator were centrally placed within their respective rooms (figure 1, figure 2), which made them both visible at entry/exit points of the building. In addition, the landings of these staircases where visible from the ground floor so users could see the height and endpoint of each staircase. The rooms that these two staircases were situated in both had a floor-to-ceiling clear glass window façade, which meant each room was flooded with natural daylight as well as minimal overhead lighting. The ‘Foyer Corner Staircase’ was a ground-to-top floor stairwell, which spiralled up the corner of the building with a slim clear glass window at the base of each staircase landing. This staircase did not receive as much natural light and was the only staircase in the study that was completely surrounded by whitewashed walls.

- Insert colour Figure 2 here –

Figure 2. Aesthetic appearance of the study staircases and elevator. A: The view of the Market Staircase from the Market Entry. B: The view of the Foyer Staircase and elevator from the Foyer Entry. C: The view of the Foyer Corner Staircase from the first-floor landing.

Automated Access Barrier Counts

SpeedStile FL access barriers (Gunnebo Entrance Control Ltd, Gothenburg, Sweden) were used to monitor stair and elevator entry and exit via identification card swipe access. Data analysis included working days only (midnight – midnight) within academic semesters at Pre-Covid-19 baseline (6th January 2020 – 20th March 2020; UK Government announced the first Covid-19 lockdown on 23rd March 2020) and Post-Covid-19 intervention (28th September 2020 – 4th December 2020, the University ceased face-to-face teaching on 7th December 2020 in accordance with UK Government student travel window guidance). To examine change over time, the intervention phase was split into two stages; First Intervention Month (28th September – 30th October 2020) and Second Intervention Month (2nd November – 4th December 2020). Access barriers were designed to open for one person per identification card. There is anecdotal evidence to suggest that multiple people could pass through an access barrier at once in cases where people had forgotten their identification. This breaking of the rules, however, is considered rare and could not be accounted for in the analysis. Manual access barrier counts were planned for January to March 2021 to validate the percentage of people only accessing the ground floor staff office and toilets at the 'Market Stairs' access barriers. However, England entered a national lockdown on 4th January 2021, which prevented the return of non-essential face-to-face teaching. Therefore, validation of the purpose for using the 'Market Stairs' access barriers could not be conducted, but anecdotally it was felt that sole access to the staff office or toilets was minimal and would likely be consistent across baseline and intervention settings. Thus, it was assumed that 'Market Stairs' access barrier use was a product of staircase use.

Statistical Analysis

Statistical analysis was conducted using SPSS version 26 (IBM, New York, USA) [8]. Total stair-use and individual staircase use were calculated as a ratio of elevator use for Ascending and Descending in order to circumvent biases relating to day-to-day changes in the volume of people using the building [9]. Parametricity was assessed with Shaprio-Wilk and Levene's Tests. One-way analysis of variance (ANOVA) tests were used with a Bonferroni post hoc to examine the difference in total stair-to elevator use ratio between Baseline, First Intervention Month, and Second Intervention Month. The Welch's F output was used as there was an inequality of variance. Individual staircase to elevator use ratio violated Shaprio-Wilk, Levene's, and Mauchly's Test of Sphericity therefore, non-parametric statistics were performed. A Kruskal-Wallis Test with a Bonferroni correction was performed for each staircase to examine the change in staircase to elevator use ratio between Baseline, First Intervention Month, and Second Intervention Month. A Freidman's Test was used to compare the difference between each staircases' ratios within each study phase (Baseline, First Intervention Month, and Second Intervention Month). Statistical steps were performed separately for Ascending and Descending. Results are presented as Mean ± Standard Error or Median (Interquartile Range) for parametric or non-parametric data, respectively, unless stated otherwise. Significant was set at p = 0.05.

Results

Absolute Counts

Across 105 observation days, there was 569,396 automated counts made up of 209,694 elevator and 359,702 staircase uses (table 2). The elevators were more frequently used to ascend from, rather than descend to, the ground floor across all study periods. Descending the stairs to, rather than ascending from, the ground floor tended to occur more frequently across study periods and individual staircases, excluding the Foyer Stairs at Baseline and the Market Stairs at First and Second Intervention Month (table 2).

Table 2. Absolute automated counts ground floor across study conditions on weekdays during academic years.

- **Insert Table 2 here -**

Total Stair to Elevator Use Ratio

Ascending

For Ascending, there was a significant increase in total stair to elevator use ratio ($F(2,34.98) = 100.03$, $p < 0.001$). At Baseline, 1.36 ± 0.02 (95% confidence interval 1.33 – 1.39) people ascended from the ground floor via a staircase for every one person who used the elevators. In the First Intervention Month, the use of staircases significantly increased by 1.28 ± 0.07 (95% confidence interval 1.12 – 1.44, $p < 0.001$) people as 2.64 ± 0.09 (95% confidence interval 2.45 – 2.83) people ascended from the ground floor via a staircase for every one person who used the elevators. Total stair to elevator use ratio remained statistically higher in the Second Intervention Month than Baseline (mean difference 0.27 ± 0.07 [95% confidence interval 0.11 – 0.43], $p < 0.001$). However, the ratio in the Second Intervention Month was statistically lower than the First Intervention Month (mean difference -1.01 ± 0.08 [95% confidence interval -1.20 - -0.82], $p < 0.001$). During the Second Intervention Month, 1.63 ± 0.06 (95% confidence interval 1.51 – 1.74) people ascended from the ground floor via a staircase for every one person who used the elevators (table 3).

Descending

For Descending, there was a significant increase in total stair to elevator use ratio ($F(2,33.13 = 102.97$, $p < 0.001$). At Baseline, 1.88 ± 0.02 (95% confidence interval 1.84 – 1.92) people descended to the ground floor via a staircase for every one person who used the elevators. In the First Intervention Month, the use of staircases significantly increased by 2.08 ± 0.14 (95% confidence interval 1.73 – 2.43, $p < 0.001$) people as 3.96 ± 0.22 (95% confidence interval 3.51 – 4.41) people

descended to the ground floor via a staircase for every one person who used the elevators. Total stair to elevator use ratio remained statistically higher in the Second Intervention Month than Baseline (mean difference 1.17 ± 0.14 [95% confidence interval 0.82 – 1.51], *p* <0.001). However, the ratio in the Second Intervention Month was statistically lower than the First Intervention Month (mean difference -0.91 ± 0.17 [95% confidence interval -1.32 - -0.51], *p* <0.001). During the Second Intervention Month, 3.05 ± 0.52 (95% confidence interval 2.83 – 3.26) people descended to the ground floor via a staircase for every one person who used the elevators (table 3).

Individual Staircase to Elevator Use Ratio

Ascending

In the First Intervention Month there was a significant increase in stair to elevator use ratio for the Foyer Stairs, in comparison to Baseline (0.83 (0.31) [95% confidence interval 0.76 – 0.93], 0.56 (0.06) [95% confidence interval 0.55 – 0.57], respectively, *adjusted p* <0.001). In the First Intervention Month, 0.83 people were using the Foyer Staircase to ascend from the ground floor, for every one person who used the elevators. However, in the Second Intervention Month, use of the Foyer Staircase significantly decreased below Baseline stair to elevator use ratio (0.42 (0.14) [95% confidence interval 0.39 – 0.46], 0.56 (0.06) [95% confidence interval 0.55 – 0.57], respectively, *adjusted p* <0.001; table 3).

There was no change in Foyer Corner Stairs stair to elevator use ratio, for the First Intervention Month, in comparison to Baseline (0.07 (0.04) [95% confidence interval 0.06 – 0.08], 0.07 (0.02) [95% confidence interval 0.07 – 0.08], respectively, *adjusted p* = 0.535). However, there was a significant decline in stair to elevator use ratio in the Second Intervention Month (0.05 (0.02) [95% confidence interval 0.04 – 0.07]) in comparison to Baseline (*adjusted p* <0.001) and the First Intervention Month (*adjusted p* = 0.009; table 3).

In the First Intervention Month there was a significant increase in stair to elevator use ratio for the Market Stairs, in comparison to Baseline (1.75 (0.46) [95% confidence interval 1.61 – 1.85], 0.71 (0.11) [95% confidence interval 0.70 – 0.74], respectively, *adjusted p* <0.001). In the First Intervention Month, 1.75 people ascended from the Ground Floor via the Market Staircase for every one person who used the elevator. In the Second Intervention Month, stair to elevator use ratio remained significantly higher than Baseline (1.08 (0.29) [95% confidence interval 1.06 – 1.23], 0.71 (0.11) [95% confidence interval 0.70 – 0.74], respectively, *adjusted p* <0.001). However, the Second Intervention Month stair to elevator use ratio was significantly lower than the First Intervention Month (*adjusted p* = 0.025; table 3).

At Baseline, First Intervention Month, and Second Intervention Month, the Market Stairs was used most for ascent, followed by the Foyer Stairs and Foyer Corner Stairs (all *adjusted p* ≤ 0.01; table 3).

Descending

In the First Intervention Month there was a significant increase in stair to elevator use ratio for the Foyer Stairs, in comparison to Baseline (1.24 (0.53) [95% confidence interval 1.15 – 1.52], 0.67 (0.08) [95% confidence interval 0.66 – 0.69], respectively, *adjusted p* < 0.001). In the First Intervention Month 1.24 people descended to the ground floor via the Foyer Stairs for every one person who used the elevators. In the Second Intervention Month stair to elevator use ratio remained statistically higher than Baseline (0.90 (0.27) [95% confidence interval 0.86 – 1.01], 0.67 (0.08) [95% confidence interval 0.66 – 0.69], respectively, *adjusted p* < 0.001) and similar to the ratio during the First Intervention Month (*adjusted p* = 0.113; table 3).

In the First Intervention Month there was a significant increase in stair to elevator use ratio for the Foyer Corner Stairs, in comparison to Baseline (0.36 (0.21) [95% confidence interval 0.33 – 0.43], 0.19 (0.03) [95% confidence interval 0.18 – 0.20], respectively, *adjusted p* <0.001). In the First Intervention Month 0.36 people descended to the ground floor via the Foyer Corner Stairs for every one person who used the elevator. In the Second Intervention Month stair to elevator use ratio

remained statistically higher than Baseline (0.28 (0.11) [95% confidence interval 0.26 – 0.34], 0.19 (0.03) [95% confidence interval 0.18 – 0.20], respectively, *adjusted p* <0.001) and similar to the ratio during the First Intervention Month (*adjusted p* = 0.495; table 3).

In the First Intervention Month there was a significant increase in stair to elevator use ratio for the Market Stairs, in comparison to Baseline (2.16 (0.81) [95% confidence interval 2.00 – 2.48], 1.00 (0.10) [95% confidence interval 0.98 – 1.03], respectively, *adjusted p* <0.001). In the First Intervention Month 2.16 people descended to the ground floor via the Market Stairs for every one person who used the elevator. In the Second Intervention Month stair to elevator use ratio remained statistically higher than Baseline (1.77 (0.47) [95% confidence interval 1.66 – 1.95], 1.00 (0.10) [95% confidence interval 0.98 – 1.03], respectively, *adjusted p* <0.001) and similar to the ratio during the First Intervention Month (*adjusted p* = 5.43; table 3).

At Baseline, Intervention Month 1, and Intervention Month 2, the Market Stairs was used most for descent, followed by the Foyer Stairs and Foyer Corner Stairs (all *adjusted p* ≤ 0.01; table 3).

Table 3. Mean or median stair to elevator use ratio for each staircase and total stair-use at baseline, first intervention month, and second intervention month. Data displayed as mean ± standard error or median (interquartile range).

- **Insert Table 3 here -**

In summary, implementation of HM Government Covid-19 building regulations was successful at increasing stair use within a UK Higher Education setting for at least 10 weeks. Notably, increases in individual staircase descent were maintained across the two intervention months whilst stair ascent decreased in the Second Intervention Month after an initial increase in the First Intervention Month. Please note, the stair to elevator use ratio has been graphically represented in the Available Data File as a continuous variable to show day-to-day changes over time and an infographic summary of the project can be found in Supplementary Material.

Discussion

In this study, we have demonstrated that stair use could be increased in a Higher Education institution building by implementing the one-way system and stair promotion signage that were recommended in Government guidance for safe office and contact centre working during Covid-19 [3]. This study provides timely evidence for Government agencies who are continually reviewing and updating their Covid-19 guidance in light of new evidence or tier restriction policies/law. It is important to note the uniqueness of this intervention period, as previous health interventions have only addressed stair use and not applied specific restrictions to elevator use. The feasibility of restrictions to elevator use remaining post COVID-19 is unknown, but the present study offers an understanding of the impact of a novel set of restrictions on activity at a University. Interventions should give careful consideration to the use of elevator restrictions as these could have discriminatory consequences to members of the community who rely on elevators to navigate between floors.

Public preference to descend rather than ascend stairs

Across all study phases, the public consistently favoured descending rather than ascending the stairs as evidenced by the difference in automated counts. Some of this apparent preference will be explained by members of the public origins and destinations of their journey however, from a physical activity and health perspective, this finding is not surprising. Descending stairs is associated with lower energy requirements in comparison to ascending stairs. In middle aged adults from Singapore (44.1 ± 13.4 years), descending 11 stories of stairs required 39% of maximum aerobic capacity and 58% of maximum heart rate in comparison to 50% and 65%, respectively, for ascending [10]. Although both ascent and descent are of sufficient intensity, 9.6 and 4.9 metabolic equivalent tasks, respectively [10], to meet government physical activity aerobic guidelines [11], descending the stairs has been associated with greater metabolic health improvements, albeit evidence is limited to older adult obese women [12]. Furthermore, lower intensity exercise has been positively associated

with long-term adherence [13] and this finding is demonstrated by the current study, as the Second Intervention Month descending stair to elevator use ratio remained similar to the Frist Intervention Month whilst ascending stair to elevator use ratio in the Second Intervention Month decreased in comparison to the First Intervention Month. Therefore, long-term strategies for safe Covid-19 building regulations and physical activity promotion, which is essential for reducing the risk of adverse Covid-19 outcomes, may see greater public adherence for stair descending and thus regular updates to stair ascent advocacy (after at least five weeks) could be required to attain similar levels of adherence.

Reductions in stair-use over time and options to overcome this issue

The data revealed a reduction in stair-use between the First Intervention Month and Second Intervention Month. This is similar to other stair use research, which found there was a ceiling effect when promotional signage was used, especially where there was a high use of stairs at baseline in a workplace setting [14]. The authors suggested such interventions could be viewed as 'nagging' and have a negative effect by reducing stair use and that careful consideration of the target population is required in order to effect a positive change in behaviours [14]. A report by Health and Social Care [15] indicated that those who may be most influenced to increase stair use by interventions are those who are physically inactive, those in the 25-35 age group, and women. Future interventions may need to consider targeted messaging rather than adopting a blanket approach to increasing stair use.

Furthermore, a more nuanced understanding of the environment may support stair use, in a busy workplace, where wait times for an elevator might be long or unknown, stair use may increase [16], with the use of buildings changing at different times of the day [9]. During the First and Second Intervention Months, the number of people in the Learning Hub was reduced due to Covid-19, with many staff, students and visitors choosing to stay at home or limit their visits to the campus. This reduction in the numbers of people in the building could also be an influencing factor for the decline

in stair use during the Second Intervention Month, which was at the time of the second Covid-19 lockdown, where the sum of elevator and staircase use was 2,447 counts less than in the First Intervention Month. However, without unique identification of stair and elevator users, there is no certainty that this lower count in Intervention Month 2 was a result of less people in the building or less repeat usage by visitors. Exploring whether targeted messages at specifically busy and quiet times could influence stair use could be worth further investigation.

Finally, the effectiveness of such interventions has also been found to be reliant on the message and the format of the message. In a review of 67 stair use studies [17], a range of approaches to promote stair use were identified, including signage, environmental changes (artwork, music, improving the aesthetic of the stairs), point of decision prompts, role modelling and promotional events, with signage the most frequently used approach. The review reported on the importance of both the message and the aesthetics of stair promotional signage in increasing the impact on stair use, with messages about potential benefits in terms of time and fitness being more effective than health messages. The visuals of the signage also proved important, with size and number of messages showing greater effects. Taşkale [18] also found point of decision prompts can encourage greater use of stairs, by acting as a 'cue' to identify the stairs as an option, while Lee *et al.* [19] report on the need for ongoing signage use to have a greater sustained impact on stair use. However, Engelen *et al.* [9] recommend greater innovation and interactivity is required to promote stair use. They reported, through observations, that few people looked at the signage or changed direction if they saw it, and suggested the use of interactive artwork, prompts through smartphones or games, and peer role models may be a more sustainable solution.

Reasons for a preference to certain staircases

From the findings of the current study, it was evident that stair to elevator use varied amongst staircases across the study period. The Market Stairs (see figure 1 for floorplan) had the largest increase in ascent stair to elevator use ratio throughout the two intervention months in comparison

to the Foyer and Foyer Corner Staircases. This is likely due to the close proximity (less than 5 metres) of the Market Stairs to the new main entrance, which was introduced after the closure of the original main Foyer Entrance, as an increasing distance between entry points and stairwells has been negatively associated with stair use (adjusted odds ratio: 0.985 [95% confidence interval: 0.985 – 0.985]) [20]. The retro-fitting of a one-way system made the Market Stairs the primary visual cue upon entry into the Learning Hub (see: [21]) and located the elevators out of direct view from the building's entrance, which is recommended by the City of New York's Active Design Guidelines [5] to promote stair-use. Further supporting evidence of stairwell visibility from lobby entrances has demonstrated an increased odds ratio of stair use by 21% (95% confidence interval: 19% - 23%) [20]. Users of the Learning Hub would only see stair promoting signage when they were standing by an elevator therefore, it seems likely that the introduction of the one-way system, which subsequently created an environment where the Market staircase was the most direct and visible path of travel for visitors to ascend up the building's floors, was the main determinant for the increase in stair ascent to elevator use ratio.

Notably, there was also a large increase in people using the Market Stairs to descend to the Ground Floor. There could be several reasons for this such as the familiarity of the staircase within the main entrance corridor that helped orientate visitors when navigating the building. In addition, the Market Entry also provided access to the campus restaurant, thus the Market Stairs would have been the most direct route for people on the upper floors. In addition, although the Market Entry was part of the one-way system, it was still possible to exit the building through these doors, though it was not encouraged. Once again, the Market Entry provided the most direct exit route out of the building to the on-campus halls of residence and the bus stops and therefore, people may have opted to use the Market Entry to exit the building instead of the Foyer Entry (see: [22]). However, we were unable to monitor building entry and exit so we cannot be certain as to whether this was the reason for the increase in Market Staircase descent.

Strengths and limitations

The main strength of this research is that it demonstrated the effect of Covid-19 policies in practice, thus evidencing the efficacy of Government guidance for safe office working during Covid-19 and future viral pandemics. The use of automated identification card access barriers at elevator and staircase entrance ways meant pre-Covid-19 elevator and stair use could be estimated and easily compared to post-Covid-19 use. Furthermore, the longitudinal design of the study allowed for change in adherence over time to be monitored to determine long-term efficacy of Government guidance.

Due to new lockdown restrictions being imposed in England on 4th January 2021, it meant the longitudinal data collection was shortened by three months and we were unable to conduct manual observations to triangulate the automated access barrier counts. The lack of manual observations also meant we were unable to determine whether members of the public changed their decision to use the elevator once they saw the "Please use stairs if possible" and "Please only use the lift if you are unable to take the stairs" signage or their adherence to the "Only 1 person per lift at any time" rule. In addition, we could not identify essential elevator use, such as carrying heavy loads or limited mobility of users. Finally, the current study only monitored ascent from and descent to the Ground Floor, thus we cannot be sure whether stair to use ratio changed on the other four stories of the building. A further limitation is the design of the intervention which was implemented with elevator restrictions and stair signage simultaneously. Identification of whether one measure was more effective than another would be an area for future research to consider. Future research could stagger the interventions implemented within the current study to determine which aspect of the intervention is most effective at increasing stair-use in differing building layouts.

Guidance for future policy

In addition to the guidance provided in HM Government Covid-19 guidance documents for safe working [3], the current study's findings supports further author recommendations to increase stair use:

- Where possible, use a building entrance that is close to a staircase as the main entrance point for a one-way system to encourage stair over elevator use.
- Update stair promotion materials at least every five weeks to potentially maintain increases in stair ascent.
- Stair descent may be maintained over at least 10 weeks and thus changes to advocacy materials may not be required on higher floors.
- Even when Covid-19 restrictions are no longer required, physical activity is still an essential component of a healthy lifestyle and thus, businesses should use stair-use promotion to instil societal norms of health-enhancing behaviours.

Conclusions

Overall, the current study has demonstrated that putting HM Government 'Covid-19 safe' offices and contact centre policies into practice is effective at increasing stair-use within a UK Higher Education setting. Closer proximity of staircases to entrances, through the creation of one-way systems, and the use of stair promoting signage likely led to the increase in stair-use to ascend and descend from the Ground Floor, with the latter being adhered to for a longer duration. Physical activity is an essential component of a healthy lifestyle and reduces the risk of adverse Covid-19 effects. Organisations should continue to implement promotional signage and prominent staircases by building entrances, even if Covid-19 regulations are removed, to encourage physical activity and enforce societal norms. Our follow-up Sport and Physical Activity Group (SPAG) project will now begin to examine peoples' experiences and motivations to use the stairs instead of the elevators at the University during the Covid-19 pandemic, as part of a stair promoting strategy to implement across the university buildings.

Funding Source/Trial Registration

This research did not receive any funding. The research was retrospectively registered at OSF Registries: www.osf.io/x2dps

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Data Statement

Accompanying dataset can be accessed in the University's public repository: https://doi.org/10.24339/a2b7d09a-ea74-4791-8659-733fdb91c79d.

References

1. Sport England. *Active Lives Adult Survey: Mid-March to Mid-May 2020. Coronavirus (Covid - 19) Report.*; 2020. https://sportengland-production-files.s3.eu-west-2.amazonaws.com/s3fs-public/2020-01/active-lives-adult-may-18-19-report_1.pdf?ehS5l7YBm3YeLHgNwXLmUSbTZPENafJY. Accessed January 26, 2021.
2. Townsend N, Foster C. *Physical Inactivity: Economic Costs to NHS Clinical Commissioning Groups.*; 2016. www.gov.uk/phe. Accessed February 4, 2021.
3. HM Government. *Working Safely during COVID-19 in Offices and Contact Centres.*; 2020. https://assets.publishing.service.gov.uk/media/5eb97e7686650c278d4496ea/working-safely-during-covid-19-offices-contact-centres-041120.pdf. Accessed January 18, 2021.
4. Bauman A, Milton K, Kariuki M, Fedel K, Lewicka M. Is there sufficient evidence regarding signage-based stair use interventions? A sequential meta-Analysis. *BMJ Open*. 2017;7(11). doi:10.1136/bmjopen-2016-012459
5. The City of New York. *Active Design Guidelines*. New York, New York, USA; 2010. https://centerforactivedesign.org/guidelines/. Accessed January 25, 2021.
6. University of Northampton. Just explore | Virtual Tour - University of Northampton. https://tour.northampton.ac.uk/just-explore. Published 2020. Accessed February 11, 2021.

7. Ryan DJ, Elliott-King J, Ward A. OSF Registries | The influence of Covid-19 building restrictions on physical activity promotion through increased stair-way use and limited elevator access, a quasi-experimental study – A SPAG active campus project. https://osf.io/ncxzj. Published 2021. Accessed February 11, 2021.

8. IBM. SPSS Statistics version 26. 2018. https://www.ibm.com/uk-en/products/spss-statistics.

9. Engelen L, Gale J, Chau JY, Bauman A. Are motivational signs to increase stair use a thing of the past? A multi-building study. *Heal Promot J Aust*. 2017;28(3):178-184. doi:10.1071/HE16107

10. Teh KC, Aziz AR. Heart rate, oxygen uptake, and energy cost of ascending and descending the stairs. *Med Sci Sports Exerc*. 2002;34(4):695-699. doi:10.1097/00005768-200204000-00021

11. Davies DSC, Atherton F, McBride M, Calderwood C. *UK Chief Medical Officers' Physical Activity Guidelines*.; 2019. https://www.gov.uk/government/publications/physical-activity-guidelines-uk-chief-medical-officers-report. Accessed January 6, 2020.

12. Chen TC, Hsieh CC, Tseng KW, Ho CC, Nosaka K. Effects of descending stair walking on health and fitness of elderly obese women. *Med Sci Sports Exerc*. 2017;49(8):1614-1622. doi:10.1249/MSS.0000000000001267

13. Dishman RK, Buckworth J. Increasing physical activity: A quantitative synthesis. *Med Sci Sports Exerc*. 1996;28(6):706-719. doi:10.1097/00005768-199606000-00010

14. Åvitsland A, Solbraa AK, Riiser A. Promoting workplace stair climbing: Sometimes, not interfering is the best. *Arch Public Heal*. 2017;75(1):2. doi:10.1186/s13690-016-0170-8

15. Health and Social Care. *A Guide to Implementing a Workplace Based Stair Use Programme*.; 2017. https://www.publichealth.hscni.net/sites/default/files/Taking_the_stairs_guide final.pdf. Accessed February 4, 2021.

16. Puig-Ribera A, Señé-Mir AM, Taylor-Covill GAH, et al. Signage interventions for stair climbing at work: More than 700,000 reasons for caution. *Int J Environ Res Public Health*. 2019;16(19):3782. doi:10.3390/ijerph16193782

17. Jennings CA, Yun L, Loitz CC, Lee EY, Mummery WK. A Systematic Review of Interventions to Increase Stair Use. *Am J Prev Med*. 2017;52(1):106-114. doi:10.1016/j.amepre.2016.08.014

18. Taşkale N. The effects of point of decision prompts on stair use from the perspective of health psychology. *Turkey J Public Heal*. 2016;14(2):95-114. https://dergipark.org.tr/en/pub/tjph/issue/24144/256238. Accessed February 4, 2021.

19. Lee KK, Perry AS, Wolf SA, et al. Promoting routine stair use: Evaluating the impact of a stair prompt across buildings. *Am J Prev Med*. 2012;42(2):136-141. doi:10.1016/j.amepre.2011.10.005

20. Ruff RR, Rosenblum R, Fischer S, Meghani H, Adamic J, Lee KK. Associations between building design, point-of-decision stair prompts, and stair use in urban worksites. *Prev Med (Baltim)*. 2014;60:60-64. doi:10.1016/j.ypmed.2013.12.006

21. University of Northampton. Learning Hub study space | JUST EXPLORE. | Virtual Tour - University of Northampton. https://tour.northampton.ac.uk/just-explore/lh-study-space. Published 2020. Accessed February 11, 2021.

22. University of Northampton. Delapre Walk | JUST EXPLORE. | Virtual Tour - University of Northampton. https://tour.northampton.ac.uk/just-explore/delapre-walk-2. Published 2020. Accessed February 11, 2021.

Building Entry/Exit Points	**Pre-Covid-19 (baseline)**	**Post-Covid-19 (intervention)**
Foyer Entry	Entry/Exit	Exit Only
Market Entry	Entry/Exit	Entry/Fire Exit
24-hour Entry	Entry/Exit	Entry/Fire Exit
Restaurant Entry	Entry/Exit	Exit Only
	Number of Access Barrier Lanes	
Floor Ascending/Descending Points	**Pre-Covid-19 (baseline)**	**Post-Covid-19 (intervention)**
Foyer Elevators	6 Ascending/ Descending	3 Ascending 3 Descending
Foyer Stairs	4 Ascending/ Descending	2 Ascending 2 Descending
Foyer Corner Stairs	2 Ascending/ Descending	1 Ascending 1 Descending
Market Stairs	3 Ascending/ Descending	2 Ascending 1 Descending
Market Mezzanine Stairs*	2 Ascending/ Descending	Closed

* Not Analysed.

	Baseline Pre-Covid-19 (*n*)		**First Intervention Month Post-Covid-19 (*n*)**		**Second Intervention Month Post-Covid-19 (*n*)**	
	Ascending	**Descending**	**Ascending**	**Descending**	**Ascending**	**Descending**
1. Elevator	96,197	78,411	8,426	6,435	11,265	8,960
2. Foyer Stairs	53,868	52,825	7,106	7,954	4,716	6,084
3. Foyer Corner Stairs	7,026	15,272	577	2,243	613	1,966
4. Market Stairs	68,914	78,454	14,394	13,302	12,653	11,735
Total Stair-Use	129,808	146,551	22,077	23,499	17,982	19,785

Staircase	Baseline (Pre-Covid-19)		Intervention Month 1 (Post-Covid-19)		Intervention Month 2 (Post-Covid-19)	
	Stair to Elevator Use Ratio					
	Ascend	Descend	Ascend	Descend	Ascend	Descend
2. Foyer Stairs	0.56 (0.06)[c]	0.67 (0.08)[c]	0.83 (0.31)[ac]	1.24 (0.53)[ac]	0.42 (0.14)[abc]	0.90 (0.27)[ac]
3. Foyer Corner Stairs	0.07 (0.02)[cd]	0.19 (0.03)[cd]	0.07 (0.04)[cd]	0.36 (0.21)[acd]	0.05 (0.02)[abcd]	0.28 (0.11)[acd]
4. Market Stairs	0.71 (0.11)	1.00 (0.10)	1.75 (0.46)[a]	2.16 (0.81)[a]	1.08 (0.29)[ab]	1.77 (0.47)[a]
Total Stairs	1.36 ± 0.02	1.88 ± 0.02	2.64 ± 0.09[a]	3.96 ± 0.22[a]	1.63 ± 0.06[ab]	3.05 ± 0.52[ab]

[a] Significantly different from Baseline. [b] Significantly different from Intervention Month 1. [c] Significantly different from Market Stairs. [d] Significantly different from Foyer Stairs. $P < 0.05$.